Preliminary acritarch and chitinozoan distributions across the Ordovician–Silurian boundary stratotype at Dob's Linn, Scotland

G. M. Whelan

Department of Geology, Glasgow University, Glasgow G12 8QQ.

Synopsis

Palynomorph distribution has been investigated across the Ordovician–Silurian boundary at Dob's Linn, where the Hartfell Shale and Birkhill Shale are well exposed. Samples were taken from the *anceps*, *extraordinarius*, *persculptus*, and *acuminatus* graptolite Biozones at the stratotype Linn Branch section and also the Main Cliff. Graptolite debris is the dominant component of the organic fraction, but acritarchs, chitinozoans and scolecodonts also occur in small numbers. Although it has not been possible to define the position of the Ordovician–Silurian boundary by microflora, the presence of palynomorphs indicates that detailed sampling might provide the stratigraphical resolution necessary to do this.

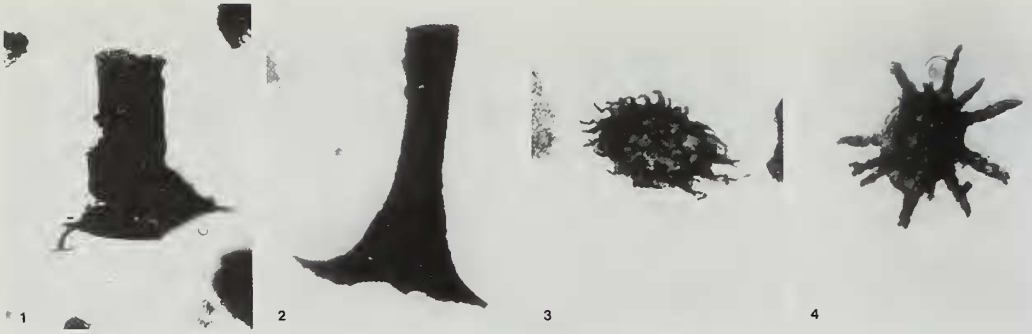
At Dob's Linn in the Southern Uplands of Scotland, continuous sections through the Hartfell and Birkhill Shales (Caradoc to Llandovery) bracket the Ordovician–Silurian boundary. These shales are replaced vertically by greywackes (the Gala Greywackes) in the *maximus* Zone. Fault bounded tracts showing similar transitions are common in the Southern Uplands. Systematic variations in the regional timing of this transition, and the complex younging relationships between and within tracts, are thought to reflect the progressive growth of an accretionary prism (McKerrow *et al.* 1977) during closure of the Iapetus Ocean. The 90 m of Hartfell and Birkhill Shales exposed here (Williams 1981) represent a substantially condensed sequence, as an equivalent sequence a hundred kilometres to the west, at Girvan, is over 3000 m thick.

This is a preliminary report of the distribution of acritarchs and chitinozoans across the newly formalized Ordovician–Silurian boundary at Dob's Linn. Data from the *anceps*, *extraordinarius*, *persculptus* (all Ordovician) and *acuminatus* (Silurian) graptolite Biozones are presented. Palynomorphs were recovered from hydrofluoric and hydrochloric acid-etched residues and studied using the scanning electron microscope, or transmitted light microscope. Whilst graptolites are common at Dob's Linn, and other fossils, such as scolecodonts, have been found sporadically, this is the first major palynological survey that has been undertaken on the Ordovician and the basal Silurian there.

The older Upper Hartfell Shale is a sequence (28 m thick) of finely bioturbated massive grey mudstones (Williams & Rickards 1984), with subordinate thin black shale bands (two *complanatus* bands, five *anceps* bands and one *extraordinarius* band), and metabentonite horizons. The Birkhill Shale (48 m) comprises a laminated, pyritous, black shale with abundant graptolites, and representing the *persculptus* to *maximus* Zones. The systemic boundary of the Ordovician–Silurian has been fixed at the base of the *acuminatus* graptolite Biozone, 1·6 m above the base of the Birkhill Shale (Cocks 1985).

Samples have been collected from two localities spanning the boundary, the Main Cliff and the Linn Branch section (the world stratotype of the Ordovician–Silurian Boundary). At Main Cliff the *wilsoni* to *acuminatus* graptolite Zones are exposed, and although some strike slip faulting has caused repetition of the upper *anceps* and *extraordinarius* black shale bands, the beds are consistently the right way up (Williams 1980). At the Linn Branch, the *anceps* to *maximus* Zones are present, and although the beds are overturned, the stratigraphy is not complicated by repetition. To date sampling has concentrated on the *extraordinarius* and *anceps* Zones. However, work in progress aims to characterize the distribution of palynomorphs across the boundary.

Bull. Br. Mus. nat. Hist. (Geol) **43**: 41–44 Issued 28 April 1988



Figs 1–4 Chitinozoans and acritarchs from Dob's Linn. 1, *Ancyrochitina ancyrea* (Eisenack 1931) Eisenack 1955. SU/DL/41, *acumunatus* Zone, Main Cliff, × 250. 2, *Cyathochitina kukersiana* (Eisenack 1934) Eisenack 1965. SU/DL/9, *anceps* Zone, Main Cliff, × 250. 3, *Solisphaeridium nanum* (Deflandre 1945) Turner 1984. SU/DL/12, *anceps* Zone, Main Cliff, × 530. 4, *Diexallophasis* sp. 1. SU/DL/10, *anceps* Zone, Main Cliff, × 470.

Both groups of palynomorphs are unevenly distributed throughout the two sections although they are generally more abundant at Main Cliff. Acritarchs appear to be more important and better preserved in the grey mudstones, while chitinozoans appear to be more common in the black shales, although this is not always the case. Palynomorph colour varies from grey to black within a single sample, and probably reflects differences in wall thickness.

Acritarchs can be divided into several groups (Downie *et al.* 1963): (a) **Sphaeromorphs** which are spherical. These are of limited biostratigraphical use as can be seen in Figs 1 and 2, and will not be mentioned further; (b) **Acanthomorphs** which have spines or processes; (c) **Herkomorphs** which have crested ridges forming polygonal fields; (d) **Polygonomorphs** which have a limited number of processes, usually between three and five; and (e) **Netromorphs** which are generally fusiform in shape. The Dob's Linn samples are noticeably dominated by acanthomorph acritarchs and only a few samples contain representatives of the other groups.

Anceps Zone

Six samples have been studied from Main Cliff (only one of which is a grey mudstone) and sixteen acritarch and chitinozoa taxa have been found (Fig. 5). The chitinozoans *Cyathochitina campanulaeformis* (Eisenack), *C. kukersiana* (Eisenack) and *Rhabdochitina gallica* Taugourdeau all suggest a Caradoc to Ashill age. *Hercochitina* cf. *turnbulli* Jenkins has previously been described from the Caradoc of Oklahoma (Jenkins 1969), but only one poorly preserved specimen was found at Dob's Linn. The acritarch *Solisphaeridium nanum* (Deflandre) Turner ranges from Arenig to Devonian and is therefore a poor biostratigraphical indicator. Of the other acritarchs recovered *Stellechinatum brachyscolum* Turner has been described only from the Caradoc of Shropshire (Turner 1984), and *Veryhachium reductum* (Deunff) Jekhowsky from the Tremadoc to the Silurian. *Diexallophasis* sp. 1 has also been found from the Silurian *sedgwickii* Zone and is probably a new species (pers. comms Molyneux 1986). Thus palynomorphs indicate an Upper Ordovician age for the *anceps* Zone, primarily on the evidence of chitinozoan distribution. Samples from the *anceps* Zone at the Linn Branch section have yielded no palynomorphs and this is attributed to the extreme weathering of this part of the section.

Extraordinarius Zone

The chitinozoans and the acritarch *Veryhachium corpulentum* Colbath found in this zone (Figs 5, 6) suggest a Caradoc to Ashgill age, although the acritarchs *Veryhachium lairdii* and *V. reductum* both range from Lower Ordovician to Silurian in age. The Linn Branch section has only yielded two non-sphaeromorph acritarchs: the acanthomorphs *Baltisphaeridium* sp. 1 and *Armoricanium* sp. 2 (Fig. 6).

GRAPTOLITE ZONE	SAMPLE NUMBER	LITH	CHITINOZOANS	ACANTHOMORPH ACRITARCHS	SPHAEROMORPH ACRITARCHS	OTHER ACRITARCHS
ACUMINATUS	SU DL 41		ANCYROCHITINA ANCYREA ANCYROCHITINA SP 1 KALOCHITINA SP 1		LEIOSPHAERIDIA SP 1	
PERSCULPTUS	SU DL 40		RHABDOCHITINA MAGNA		L SP 1	DICTYOTIDIUM SP 1
EXTRAORDINARIUS	SU DL 38			MULTIPLICISPHAERIDIUM SP 1	L SP 1 L SP 2 SYNSPHAERIDIUM SP 1	VERYHACHIUM LAIRDII V CORPULENTUM V REDUCTUM
	SU DL 17		CYATHOCHITINA HYMENOPHORA	MICRHYSTRIDIUM SP 1 MICRHYSTRIDIUM SP 2	L SP 1	V SP 1 ACTINOTODISSUS SP 1
	SU DL 16				L SP 1	
	SU DL 15			MULTIPLICISPHAERIDIUM SP 1	L SP 1 L SP 2	
ANCEPS	SU DL 14			MULTIPLICISPHAERIDIUM SP 1		
	SU DL 13				L SP 1 L SP 2	
	SU DL 12			SOLISPHAERIDIUM NANUM STELLECHINATUM BRACHYSCOLUM MICRHYSTRIDIUM SP 1	L SP 1 L SP 2	
	SU DL 11				L SP 1 L SP ?	
	SU DL 10			GONIOSPHAERIDIUM SP 1 DIEXALLOPHASIS SP 1 MULTIPLICISPHAERIDIUM SP 2 MICRHYSTRIDIUM SP1, M SP3	L SP 1 L SP 2	VERYHACHIUM REDUCTUM AREMORICANIUM SP 1
	SU DL 9		CYATHOCHITINA KUKERSIANA C CAMPANULAEFORMIS RHABDOCHITINA GALLICA HERCOCHITINA CF TURBULLI		L SP 1 L SP 2	

Fig. 5 Distribution of acritarchs and chitinozoans at Main Cliff, Dob's Linn. In column 3 (lithology), horizontal lines indicate a black shale sample, and the dots represent a grey mudstone.

Persculptus Zone

At Main Cliff the chitinozoan *Rhabdochitina magna* Eisenack and the herkomorph acritarch *Dictyotidium* sp. 1 have been found, while two samples from the Linn Branch section have yielded *Kalochitina* sp. 1 and *Conochitina tormentosa* Taugourdeau. This assemblage suggests a Caradoc to Ashgill age, although *Rhabdochitina magna* is known to range into the Llandovery.

Acuminatus Zone

One sample from Main Cliff has yielded 24 specimens of the important Lower Silurian form *Ancyrochitina ancyrea* (Eisenack) Eisenack and a single specimen of *Kalochitina* sp. 1. At the Linn Branch *Rhabdochitina magna* is found, and both this species and *Kalochitina* sp. 1 extend across the boundary, and are thus of little biostratigraphical use as boundary markers.

Because of the long range of most species the distributions of acritarchs and chitinozoans are less refined biostratigraphical indicators than those of graptolites. The sample from the *acuminatus* Zone can be dated accurately as Lower Silurian, while all other samples which yielded an unequivocal age determination are of Upper Ordovician age. It is important to note that the chitinozoans have proved most useful in this survey and that they are often very abundant in the black shales. As the boundary is within the Birkhill Shale, it is possible that bed by bed processing will yield sufficient chitinozoan taxa to determine the position of the Ordovician–Silurian boundary accurately in terms of the microflora. As palynomorphs often occur in rocks which lack datable macrofossils, even a crude biostratigraphical zonation based on chitinozoans would have considerable use in word-wide correlation.

GRAPTOLITE ZONE	SAMPLE NUMBER	LITH	CHITINOZOANS	ACANTHOMORPH ACRITARCHS	SPHAEROMORPH ACRITARCHS
ACUMINATUS	SU DL 38				LEIOSPHAERIDIA SP 1
	SU DL 37		RHABDOCHITINA MAGNA		
PERSCULPTUS	SU DL 36				L SP 2
	SU DL 35		KALOCHITINA SP 1		L SP 2
	SU DL 34		CONOCHITINA TORMENTOSA		L SP 2
	SU DL 33				L SP 1 L SP 2
EXTRAORDINARIUS	SU DL 32			BALTISPHAERIDIUM SP 1 AREMORICANIUM SP 2	L SP 1 L SP 2
	SU DL 31				L SP 1 L SP 2
ANCEPS	SU DL 43				

Fig. 6 Distribution of acritarchs and chitinozoa at the Linn Branch section, Dob's Linn. Lithology symbols as in Fig. 5.

Acknowledgements

I am grateful to C. J. Burton, G. B. Curry, K. J. Dorning, P. D. W. Haughton and S. G. Molyneux for their help, and I should also like to thank D. Maclean for printing the diagrams. A N.E.R.C. grant is gratefully acknowledged.

References

Cocks, L. R. M. 1985. The Ordovician–Silurian boundary. *Episodes*, Ottawa, **8:** 98–100.

Downie, C., Evitt, W. R. & Sarjeant, W. A. S. 1963. Dinoflagellates, hystrichospheres and the classification of the acritarchs. *Stanf. Univ. Publs*, Palo Alto, **17**(3): 3–16.

Jenkins, W. A. M. 1969. Chitinozoa from the Ordovician Viola and Fernvale Limestones of the Arbuckle Mountains, Oklahoma. *Spec. Pap. Palaeont.*, London, **5.** 44 pp., 9 pls.

McKerrow, W. S., Leggett, J. K. & Eales, M. H. 1977. Imbricate thrust model of the Southern Uplands of Scotland. *Nature, Lond.* **267:** 237–239.

Turner, R. E. 1984. Acritarchs from the type area of the Ordovician Caradoc Series, Shropshire, England. *Palaeontographica*, Stuttgart, (B) **190:** 87–157.

Williams, S. H. 1980. An excursion guide to Dob's Linn. *Proc. geol. Soc. Glasgow* **121/122:** 13–18.

—— (1981). The Ordovician and Lowest Silurian Graptolite Biostratigraphy in Southern Scotland. Unpublished Ph.D. Thesis, University of Glasgow.

—— **& Rickards, R. B.** 1984. Palaeoecology of graptolitic black shales. *In* D. L. Bruton (ed.), *Aspects of the Ordovician System*: 159–166. Universitetsforlaget, Oslo.